# PRACTICAL GUIDE FOR MUNICIPAL DRAINS

MINISTRY
OF AGRICULTURE AND FOOD

MINISTRY
OF THE ENVIRONMENT

MINISTRY
OF NATURAL RESOURCES

This publication was prepared by the Thames River Implementation Committee staff as a guide for landowners, engineers, contractors, and councils when constructing and maintaining open municipal drains. It is not meant to be a detailed technical manual. Local Ministry of Agriculture and Food or Conservation Authority offices should be contacted for further technical assistance.

The Thames River Implementation Committee (T.R.I.C.) was formed in 1976 to deal with problems relating to water quality and water quantity conditions in the Thames River. T.R.I.C. is composed of representatives from a number of government ministries, the Lower Thames Valley and Upper Thames River Conservation Authorities, the Ontario Federation of Agriculture, and the Municipal Engineers Association. Funding for the program is provided by the Ministry of the Environment and the Ministry of Natural Resources.

Further information on the T.R.I.C. program can be obtained from the Upper Thames River Conservation Authority, P.O. Box 6278, Station D, London, Ontario N5W 5S1.

Telephone: (519) 451-2800

DATE: SPRING, 1982.

*Cover Picture:* A drain with stable, vegetated side slopes. The buffer strip acts as a filter and also provides an occasional access road.

## INTRODUCTION

Considerable attention is currently being directed to the need for ensuring the long-term protection of our valuable agricultural soils. There is an increased awareness of the relationships between soil erosion and reduced water quality in our streams and lakes. Streambank and ditchbank erosion are significant contributors to impaired water quality that can be minimized through proper design, construction and maintenance practices. Appropriate design practices for municipal drains are recognized as a useful means of offsetting the impact of surface runoff (ie. sheet erosion) on adjacent farmland.

There are numerous reference materials about the proper means of design and construction of municipal drains. This booklet has been prepared to provide a condensed summary of the most common and effective features of drain design, construction, and maintenance which help control erosion and improve water quality.

## BENEFITS TO FARMERS FROM IMPROVED DESIGN AND CONSTRUCTION PRACTICES

Almost every farmer today pays assessment on municipal drains and many of those who pay show a serious concern for proper design, construction and maintenance practices. Proper consideration of these concerns will ensure efficient drainage systems with extended periods between major improvements.

To extend the life of an open drain, sheet erosion on adjacent lands and erosion of the ditch bottom and ditchbanks must be kept to a minimum. Sheet erosion is the soil loss caused by overland flow over a large area. Bank erosion is a result of the erosive force of the water flowing against the banks, the soil moisture conditions, and the weight of the soil itself. Erosion processes can be greatly reduced by simply modifying soil management practices. In the long term this will actually save landowners money. If erosion is reduced, sedimentation will decrease and drain cleanouts will be required less frequently.

**BENEFITS INCLUDE:**

1. **Decreased Assessment:**
   - reduced sedimentation and reduced bank erosion decrease the frequency of cleanouts and therefore costs farmers less money.
2. **Maintaining Productive Farmland:**
   - bank erosion creates vertical banks and a resulting loss of several metres of land when the ditch is reconstructed (DIAGRAM A).
   - properly shaped and vegetated ditches, and proper outlets for tile and surface water when first constructed ensure against loss of land.
   - washouts cause irregular field boundaries making the operation of field machinery difficult.
3. **Reduced Hazard:**
   - bank erosion can be reduced by cropping a safe distance away from the streambank.
   - unstable and undercut banks caused by cropping too close to the drain increase the chances of machinery overturns and possible injury.
4. **Better Drain Performance:**
   - reduced silting will keep field tile outlets working longer and decrease the time it takes for water to be removed from a field; the result can be higher crop yields and longer planting and harvest time.
5. **Water Quality Improvement:**
   - soil erosion contributes nutrients (such as phosphorus) to watercourses, producing serious water quality problems for neighbours and those farther downstream.
   - better ditches with improved soil management reduce this problem.
   - nutrients serve the farmer better in the soil than in the water.
6. **Aquatic Habitat Improvement:**
   - drains that include erosion control measures are generally cleaner, with less weed growth and fewer stagnant pools.
   - the results are reduced algae growth and a better habitat for game fish as opposed to coarse fish such as carp.

## REMEDIAL MEASURES

It is possible to correct erosion problems on a drain after it has been constructed. The most cost-effective approach, however, is to have erosion prevention measures included when a drain is new, being reconstructed, or cleaned out under an engineer's report. The inclusion of remedial measures in these reports makes them eligible for the 1/3 grant for Municipal Drains by the Ontario Ministry of Agriculture and Food (O.M.A.F.) and all assessed parties within the watershed contribute a portion of the cost. Under drain maintenance, an engineer's report is not required and only upstream landowners are assessed.

Some of the more common measures which exist to control erosion and decrease sedimentation are listed below along with their advantages, disadvantages, and costs. Less common measures exist for special problems, and these may be obtained by consulting with representatives of your local Conservation Authority, O.M.A.F., Drainage Engineers, and Drainage Superintendents. Effective erosion control may require one or more of these measures.

Costs unless otherwise noted are for materials only and do not include the cost of installation. These costs will vary with time and location of construction.

**Handseeding a bank immediately following construction ensures good seed germination.**

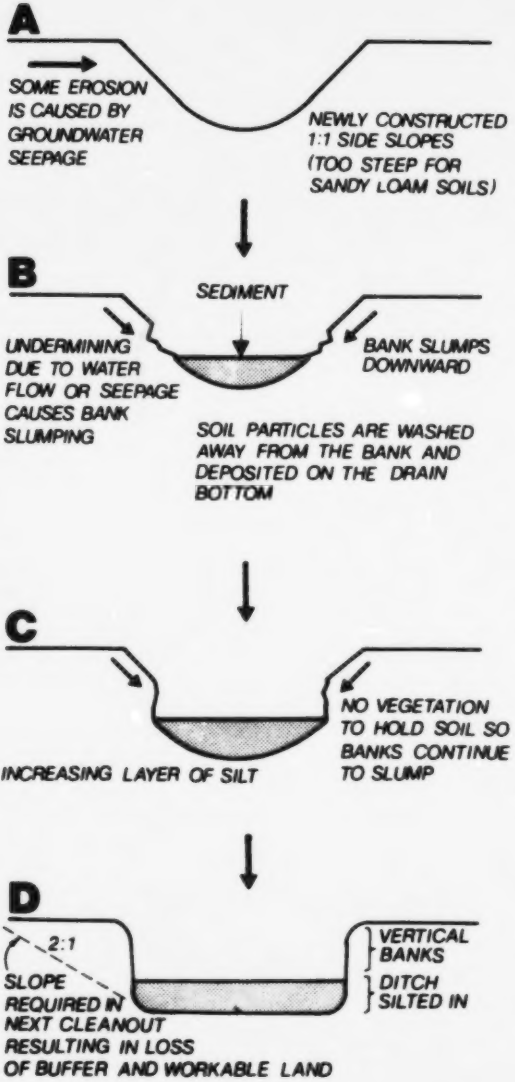

A
SOME EROSION IS CAUSED BY GROUNDWATER SEEPAGE
NEWLY CONSTRUCTED 1:1 SIDE SLOPES (TOO STEEP FOR SANDY LOAM SOILS)
B
SEDIMENT
UNDERMINING DUE TO WATER FLOW OR SEEPAGE CAUSES BANK SLUMPING
BANK SLUMPS DOWNWARD
SOIL PARTICLES ARE WASHED AWAY FROM THE BANK AND DEPOSITED ON THE DRAIN BOTTOM
C
NO VEGETATION TO HOLD SOIL SO BANKS CONTINUE TO SLUMP
INCREASING LAYER OF SILT
D
2:1
SLOPE REQUIRED IN NEXT CLEANOUT RESULTING IN LOSS OF BUFFER AND WORKABLE LAND
VERTICAL BANKS
DITCH SILTED IN

**DIAGRAM A:**

**This series of diagrams illustrates how side slopes too steep for the soil conditions will result in bank erosion and sedimentation in the drain. During the next major cleanout a substantial amount of agricultural land will be lost.**

1. **Vegetated Streambank Cover:**
The greatest amount of erosion from ditch banks occurs during the first year after construction. Grass seed should be broadcast immediately after any soil is disturbed and preferably that same working day to ensure that adequate moisture is present for seed germination. Your local Conservation Authority or O.M.A.F. office can recommend the most suitable seed mixtures. An application of a 10-10-10 or 10-20-0 fertilizer at 300-500 kg/ha and grass seed at 50-150 kg/ha will ensure a good growth. Fertilizer may not be necessary if seeding occurs immediately after construction. On most drains, the area seeded will not be large, and the potential for pollution from fertilizer being washed into the drain is very small.

**ADVANTAGES:**

- **one of the most economical and most effective means of soil stabilization.**
- **a good grass cover can be expected in the first year and will be well established in 2 - 3 years.**
- **greatly reduces drain maintenance, bank problems and the need for major reconstruction.**

**DISADVANTAGES:**

- **seed growth is partially dependent on slope, roughness and fertility of ditch bank.**
- **summer and late fall germination of certain seed varieties may be difficult.**

**COSTS:**

- **grass seed: $3.00 to $7.00 per kilogram depending on mixture used.**
- **fertilizer, if required.**

2. **Buffers:**
A vegetative strip with a minimum width of 3 meters along a drain or watercourse is an effective filter of sediment and nutrients, both of which are carried in overland flow. Buffers also decrease the velocity of the water, helping to prevent rill or gully erosion occuring on streambanks. Buffers prevent cultivation up to the edge of the streambank, a practice which weakens the top of the bank and contributes to bank failure. Buffers also allow room for future maintenance work so that disruptions to any existing crops are minimized.

**ADVANTAGES:**

- economically reduces sediment and chemical pollutants entering a drain or streamcourse by slowing and distributing overland runoff.
- adds to stability of ditchbanks.
- vegetation may be cut for hay.
- allows room for future maintenance.

**DISADVANTAGES:**

- loss of some productive land.
- requires maintenance (ie. mowing).
- care needed to prevent grass kill when spraying herbicides on adjacent fields.

**COSTS:**

- small loss of productive farmland.
- can be considered a long-term benefit which outweighs costs.

3. **Tile Outlet Protection:**
A ditchbank will begin to scour where a tile outlets directly onto the bank, unless some form of protection is provided. Where scouring

develops, sedimentation in the drain is increased, possibly forming a sand bar which deflects water flow against the opposite bank to begin an additional scouring process. Also, the tile outlet is in danger of failure which could result in the failure of the field tile draining into it. Rip rapping the area above and below the tile outlet is a good means of protecting the ditch bank from tile discharge or surface flow.

Field tile outlets to a ditch should have a minimum length of steel outlet pipe with a rodent guard. Table 1. indicates recommended outlet dimensions for various sizes. There should be no spaces left around the outlet pipe after construction. Water can travel through these spaces and cause erosion.

**TABLE 1: DIMENSIONS OF OUTLET PIPE**

| DRAIN PIPE DIAMETER (IN.) | OUTLET PIPE MIN. LENGTH (FT.) | OUTLET PIPE MIN. DIAMETER (IN.) |
|---|---|---|
| 4 | 10 | 4 |
| 6 | 10 | 6 |
| 8 | 10 | 8 |
| 10 | 12 | 10 |
| 12 | 14 | 12 |
| 14 | 16 | 15 |
| 16 | 18 | 18 |
| 18 | 20 | 18 |

(From *Drainage Guide for Ontario*, O.M.A.F., 1978, p. 12).

**ADVANTAGES:**

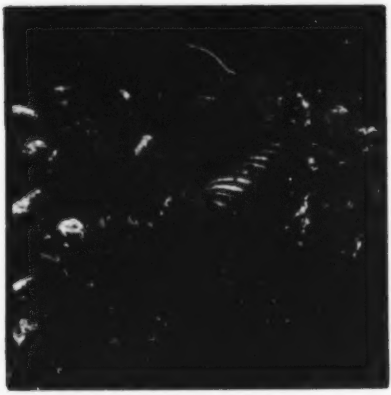
- **maintains bank stability.**
- **prevents gully formation.**
- **maintains operation of field tile.**

**DISADVANTAGES:**

- **slightly increases cost of drain construction.**

## COSTS:

- outlet pipe: approx. $42.00 for 3 m. of 200 mm pipe with wall thickness of 1.6 mm (16 ga.).
- rip rap: approx. $12.00/$m^3$ delivered to site.
- long-term benefits outweight costs.

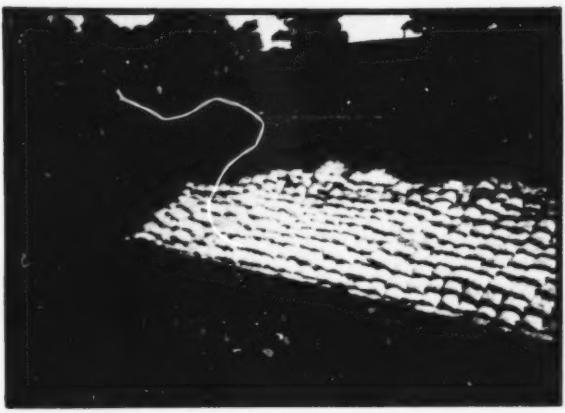


Above: Rip rap provides excellent protection against tile-flow, surface flow and seepage around tile outlets.

Below: Rip rapping is an effective and economical method of controlling ditch bank erosion, particularly where the drain curves. Note the erosion in the foreground where rip rapping was not installed.

**Gabion baskets have been placed here to provide protection for the tile outlet. Prior to its construction serious washouts occurred each spring.**

4. **Artificial Bank Protection:**
   Artificial bank protection prevents scouring action by flowing water and eliminates slumping. It is most often used where the stream channel changes course abruptly and where proper side slopes (see section 5) for bank stability cannot be constructed. Protection may be provided by rip rap (broken, angular rock, not field stone), gabions (wire baskets filled with angular rock), or sacked concrete (jute bags filled



**Sacked concrete was placed along this stream channel as protection against scouring and slumping.**

with concrete). All rip rap should be underlain by filter cloth to prevent the washout of fine soil particles and thus maintain stability. *The design of these measures requires the assistance of qualified technicians or engineers.*

### ADVANTAGES:

- controls undermining and loss of structures and usable land.
- can be used on vertical slopes (gabions only).

### DISADVANTAGES:

- rip rap requires a 2:1 bank slope or shallower.
- increases drain construction costs.

### COSTS:

- sacked concrete: approx. $\$125/m^3$ installed.
- rock rip rap: approx. $\$12/m^3$ delivered to site.
- gabions: 2m x 1m x 1m deep: $38 plus rock rip rap.
- filter: $\$1.50$ up to $\$2.75/m^2$.

5. **Proper Side Slopes**:
Table 2 gives the current O.M.A.F. recommendations for side slopes on municipal drains. These recommendations must be followed if bank stability is to be maintained. Bank protection here is defined as vegetated slopes, buffer strips, rip rap, fencing, etc.

### ADVANTAGES:

- proper slopes ensure bank stability.

### DISADVANTAGES:

- flatter slopes cause more land to be lost.
- increased land area needed to spread spoil material.

### COSTS:

- increased costs of excav .tion.
- loss of productive farm land.
- benefits can outweigh costs (long-term).

**TABLE 2**

**O.M.A.F. Recommendations (Present Practice)**

## SIDE SLOPES FOR OPEN MUNICIPAL DRAINS

| Soil Materials | Minimum Slope (horizontal: vertical) |
|---|---|
| Peat | 1:1 |
| Clayey (Greater than 35% clay) | 1.5:1 |
| Loamy (10-35% clay) | 2:1 |
| Sandy or Silty (less than 10% clay) | 3:1 |
| Clay of Marine Origin And/or Banded With Sand or Silt (Subject to Low Stability When Saturated) | 4:1 |
| Sandy or Silty With High Water Table And/Or Lateral Seepage | 4:1 |

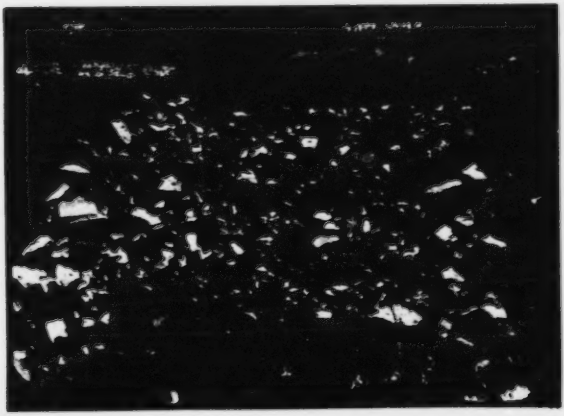
6. **Overland Flow Protection**:
The main types of control measures to offset the effects of overland flow are rock chutes, grassed waterways and drop inlets. *The design of these measures requires the assistance of qualified technicians or engineers.* Rock chutes provide erosion-resistant coverings to the ditch bank to safely transport water from agricultural land into the ditch.

Grassed waterways effectively spread large flow volumes over a wide area to reduce potentially high water velocities. Natural low runs where gullies have the potential to form are best suited for waterways. Cropping on adjacent fields should be perpendicular to it to avoid parallel rill formation. The waterway should be mowed periodically to maintain a thick growth. Swales, which are broad shallow channels having side-slopes of 10:1 or gentler, capable of being cropped after shaping, can also be used to decrease the erosive force of the water. Swales can often be an effective alternative to a permanent grassed waterway. (Grassed waterways and swales may not be necessary where conservation tillage is practiced.)

Drop inlets are pre-fabricated structures set back from the ditch edge to direct water through the ditch bank to the ditch bottom. They may be constructed of concrete, corrugated plastic or corrugated steel pipe.

**Above:** Concrete around this drop inlet provides protection against scouring.

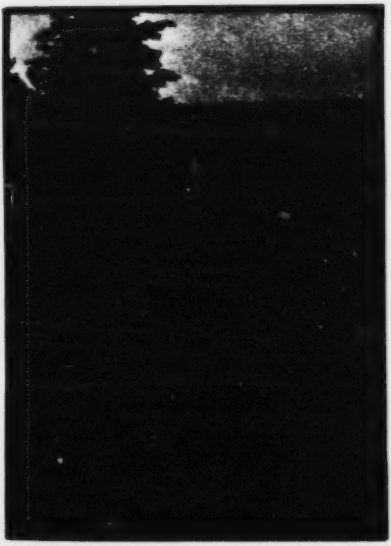
**Below:** This rock chute allows surface water to flow from the field into the ditch without harmful scouring.



Grassed waterways allow water to move across fields via a protected route.

## ADVANTAGES:

- prevents rill and gully erosion and associated soil losses.
- potential convenience compared to working around a gully.
- waterways can be cropped for hay.
- grassed waterway allows infiltration, thereby reducing runoff.
- grassed waterways prevent damage to subsurface tile.



A municipal drain with well constructed and stable side slopes. Immediate seeding will ensure future bank protection.

**DISADVANTAGES:**

- **care needed when spraying herbicides near waterways.**
- **must be maintained (i.e. mowed, fertilized).**

**COSTS:**

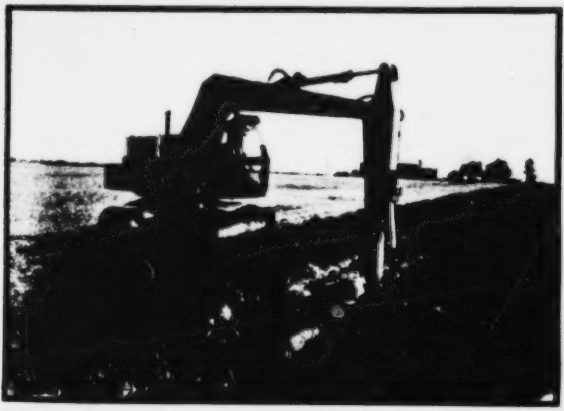
- **loss of land for waterway (which may otherwise become a gully).**
- **angular stones for rock chute: $12/m^3$ delivered to site.**
- **grass seed: $3.00 to $7.00/kg.**
- **drop inlets: approx. $100 to $300 per inlet but is dependent on the site conditions and materials used.**
- **grassed waterways: approx. $4.00 per metre for a 10 metre wide waterway (includes construction, seed and fertilizer).**

7. **Conservation Construction Practices:**
This is a miscellaneous category which includes many techniques for reducing the amount of sediment entering a stream via bank erosion, and increasing bank stability during and following ditching operations. Sediment control efficiency may be very high for low intensity storms if these techniques are applied. The major costs are those involving the time necessary to carry out these techniques. Major disadvantages are additional costs and potential inconveniences to the landowner and/or contractor.

Listed below are examples of suggested conservation practices. More exist and can be learned of through consultation with the appropriate authorities (i.e. Drainage Superintendents, O.M.A.F. engineers, Conservation Authorities, etc.).

- minimum disturbance of bank vegetation; this involves bottom cleanouts only, and one-side construction wherever possible.
- where possible, one-side construction should be on either the east or north banks to prevent sun scorching of the soil and provide shade for fish.
- bottom cleanouts should be rounded to prevent slumping. (Diagram B)

- use of hydraulic backhoes instead of draglines and smooth buckets for bottom cleanouts instead of toothed ones.
- placing interceptor tiles parallel with the ditch in areas with a high water table controls or eliminates bank slumping.
- applying mulch retains moisture and keeps soil in place during vegetative establishment.
- use of header tiles limits the number of outlets (and therefore bank excavations) entering a stream.
- time construction to avoid interfering with farmers' cropping practices (if possible) and optimum growth time for new vegetation.
- avoidance of abrupt changes in ditch cross section or bottom grade without proper rock protection.
- use of scarifiers on buckets for bank regrading to give rough surface; this gives seed a better surface on which to germinate.
- weirs or check dams may be needed where the drain grade is steep.



**Bottom cleanouts remove obstructions to water passage without disturbing stable, vegetated side slopes.**

- clear only as much land as needed to level the spoil.

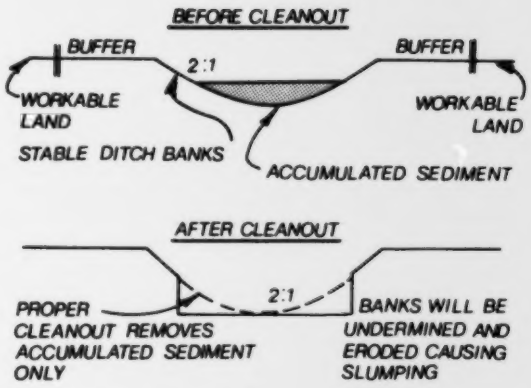



**DIAGRAM B:**

**In this situation an improper bottom cleanout has created vertical banks. The result will be undermining caused by flowing water. This results in unstable banks, erosion, and loss of agricultuarl land similar to diagram A. The proper method should be removal of accumulated sediments only.**

8. **Sediment Basins & Traps:**
In sediment-laden water, the reduction of the sediment load is desirable before it discharges into a main watercourse. The basic design requirement of a sediment basin is a large storage area to allow suspended sediment to settle. A storage basin requires maintenance and removal of debris and accumulated sediments every few years if the basin is to remain effective.

Sediment traps, such as straw bales, are usually temporary structures and are most effective where flows are low or intermittent (as in a grassed waterway immediately after construction). Stakes are used to keep these straw bales in place.

**ADVANTAGES:**

- **enhances quality of water entering stream.**
- **prevents sedimentation in drain downstream.**
- **especially effective downstream of major drain reconstruction.**
- **topsoil removed from basin can be spread on farmland.**

**DISADVANTAGES:**

- **land may not be available.**
- **not adaptable to all situations.**
- **costs may be too great in relation to overall project.**
- **difficult and expensive to remove fine particles in sediment load.**

**COSTS:**

- **varies with depth, area, accessibility of drain.**

9. **Controlled Livestock Watering:**
When livestock are allowed direct access to a watercourse for drinking, stream banks are broken down, bottom sediments are disturbed, and animal manures are directly discharged into the watercourse. The best solutions to this problem are, 1) fencing off the watercourse with the provision of alternate sources of water supply, and, 2) controlled access and provision of gravel, concrete or similar access ramps will reduce the problem, while allowing direct usage of the stream by livestock.

**ADVANTAGES:**

- **prevents bottom disturbance.**
- **maintains stable banks.**
- **reduces direct discharge of livestock wastes to watercourses.**
- **increases quality of drinking water for livestock.**

**DISADVANTAGES:**

- **increased maintenance.**
- **increased cost and inconvenience if alternate water supply is required.**
- **requires removal of debris and ice if fence is in water.**

**COSTS:**

- **fencing: $4.00/m for page wire, posts.**
  **: $2.00/m for suspension fencing.**

- **alternate watering facility (nose-pumps, pond, access ramps).**

**Unrestricted cattle access results in trampling of banks and slumping. The fenced side of the stream shows stable vegetated slopes.**

10. **Drain Maintenance:**

A well designed municipal drain will be the easiest and most economical to maintain. Even properly constructed drains, however, need to undergo drain maintenance periodically. On-going drain maintenance will ensure that the original drain investment is protected, minor erosion problems are resolved and frequency of major drain cleanouts is reduced. Specialized equipment and techniques are available to maintain the efficient operation of the drain without the loss of valuable farmland or the impairment of water quality. As of spring 1981, work done under drain maintenance is eligible for a 1/3 grant if a qualified drainage superintendent oversees the work. (Drainage Act, Section 85).

## RESPONSIBILITIES

**Certain responsibilities exist for Municipal Councils, engineers, contractors, and landowners to ensure a drain is well designed, constructed and maintained.**

**Municipal Councils:**

- hire an engineer who will comply with O.M.A.F.'s publication, *Design and Construction Guidelines.*
- hire a contractor who does quality work, ensuring fewer repairs.
- hire a qualified drainage superintendent.
- carry out a regular maintenance schedule on all municipal drains, including repairs of wash-outs and regular weed removal from ditches; incorporate this schedule into the drain by-law.
- ensure regular qualified inspection during drain construction.

**Well maintained municipal drain with adequate buffer zone.**

**Engineers:**

- include detailed specifications in report to avoid misunderstandings during construction (e.g. specify exact volume of rip rap to be used).
- specify the responsibility for regular qualified inspection to ensure report being followed.
- comply with O.M.A.F. guidelines on drainage and construction.
- include a maintenance schedule in the report.

**Contractors:**

- ensure careful movement of excavating machinery to prevent scouring of vegetated areas, bank slumping, and loss of adjacent crops.
- ensure engineer's report is followed correctly.
- demand inspection of the work and good communication of design specifications.

**Landowners:**

- ensure engineer includes in his report all erosion control measures that he may deem necessary. Measures used are eligible for a 1/3 grant when included in the report.
- do not feel intimidated at site meetings; the engineer is working for you, and where reasonable, should comply with your wishes.
- a few hours maintenance each year on a drain which runs through your property may help reduce the need for future repairs; examples are removal of brush and obstructions such as fallen trees and large stones.
- if dissatisfied with any work done, appeal to Drainage Tribunal within one year after completion of the work.
- notify Township Drainage Superintendent about major washouts, broken tiles, etc. This is the single most important means of keeping costs in drain construction to a minimum.

# METRIC MEASUREMENT CONVERSIONS

| ymbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| **ENGTH** | | | | |
| n | inches | 2.54 | centimeters | cm |
| t | feet | 30 | centimeters | cm |
| /d | yards | 0.9 | meters | m |
| mi | miles | 1.6 | kilometers | km |
| mm | millimeters | 0.04 | inches | in |
| cm | centimeters | 0.4 | inches | in |
| m | meters | 3.3 | feet | ft |
| m | meters | 1.1 | yards | yd |
| km | kilometers | 0.6 | miles | mi |
| **AREA** | | | | |
| $in^2$ | square inches | 6.5 | sq. centimeters | $cm^2$ |
| $ft^2$ | square feet | 0.09 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.8 | square meters | $m^2$ |
| $mi^2$ | square miles | 2.6 | sq. kilometers | $km^2$ |
| | acres | 0.4 | hectares | ha |
| $cm^2$ | sq. centimeters | 0.16 | square inches | $in^2$ |
| $m^2$ | square meters | 1.2 | square yards | $yd^2$ |
| $km^2$ | sq. kilometers | 0.4 | square miles | $mi^2$ |
| ha | hectares ($10,000m^2$) | 2.5 | acres | |
| **MASS (WGT.)** | | | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2,000 lbs.) | 0.9 | tonnes | t |
| | long tons (2,240 lbs.) | 1.01 | tonnes | t |
| g | grams | 0.035 | ounce | oz |
| kg | kilograms | 2.2 | pounds | lb |
| t | tonnes (1,000 kg) | 1.1 | short tons | |
| t | tonnes (1,000 kg) | 0.98 | long tons | |
| **VOLUME** | | | | |
| sp | teaspoons | 5 | milliliters | ml |
| tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons (U.S.) | 3.8 | liters | l |
| gal | gallons (Imp.) | 4.5 | liters | l |
| $ft^3$ | cubic feet | .028 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.76 | cubic meters | $m^3$ |
| ml | milliliters | 0.03 | fluid ounces | fl oz |
| l | liters | 2.1 | pints | pt |
| l | liters | 1.06 | quarts | qt |
| l | liters | 0.26 | gallons (U.S.) | gal (U.S.) |
| l | liters | 0.22 | gallons (Imp.) | gal (Imp.) |
| $m^3$ | cubic meters | 35 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.3 | cubic yards | $yd^3$ |

**USEFUL CONVERSION**

1kg /ha = 88 lb /ac

**TEMPERATURE**

$^oC = (^oF - 32) \times .555$

$^oF = (^oC \times 1.8) + 32$

List of Publications Available from the Ministry of Agriculture and Food.

Factsheets:

*Common Law Aspects of Water*
*Control of Soil Erosion*
*Drainage Law*
*Grassed Waterways*
*Understanding Drainage Assessment*

Publications:

*Design and Construction Guidelines for work under the Drainage Act.*
*Determination of Runoff from Agricultural Areas*
*Drainage Guide for Ontario*
*Farm Drainage*

**Attendance at site meetings ensures that all concerns have been considered prior to construction.**